(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 October 2002 (03.10.2002)

PCT

(10) International Publication Number
WO 02/076717 A2

(51) International Patent Classification[7]: B32B

(21) International Application Number: PCT/IL02/00235

(22) International Filing Date: 21 March 2002 (21.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/277,996	22 March 2001 (22.03.2001)	US
60/278,010	22 March 2001 (22.03.2001)	US
60/278,065	22 March 2001 (22.03.2001)	US
09/853,017	10 May 2001 (10.05.2001)	US
PCT/IL01/00758	14 August 2001 (14.08.2001)	IL

(63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:
US PCT/IL01/00758 and (CIP)
Filed on 14 August 2001 (14.08.2001)

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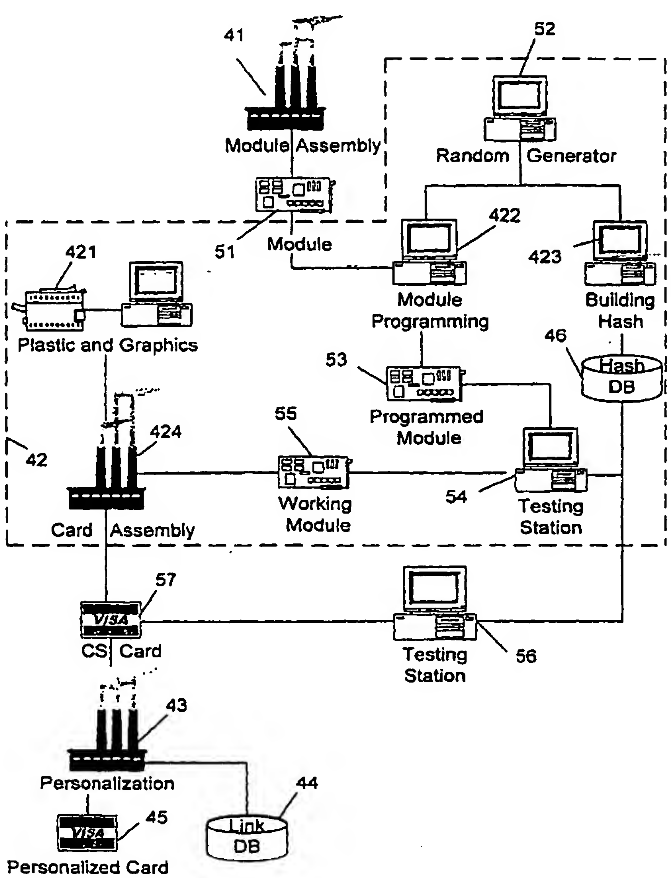
(54) Title: MANUFACTURE OF SELF-POWERED IDENTIFICATION DEVICES



(57) Abstract: A method of manufacturing an identification card. The method includes providing a substrate carrying a circuit including at least one electronic element and laminating the substrate to at least one isolating layer, using an at least partially hot lamination process, so as to form a card.

WO 02/076717 A2

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MANUFACTURE OF SELF-POWERED IDENTIFICATION DEVICES

RELATED APPLICATIONS

This application is a continuation in part of PCT/IL01/00758 filed on 14 August 2001 (14.08.01) and USSN 09/853,017 filed on 10 May 2001 (10.05.01), and claims the benefit under 119 (e) of 60/278,065 filed on 22 March 2001 (22.03.01), USSN 60/278,010 filed on 22 March 2001 (22.03.01) and USSN 60/277,996 filed on 22 March 2001 (22.03.01), the disclosures of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to manufacture methods of identification cards and particularly of self-powered identification cards.

BACKGROUND OF THE INVENTION

Usually, assembly of bank-type cards, including microprocessor cards, involves the manufacture of a plurality of card bodies in sheets. Each sheet has plurality of card bodies, for example, 7x12 cards (or 84 cards). The exact dimensions of the matrix can vary depending on production equipment of the card body producer or the type of microprocessor card. This is accomplished by machining a cavity into the body of the "dumb" credit cards, after they are fully printed, complete with logos, and signature panels, and implanting the electronics module and contact into that cavity. Thus the card is completed without exposing the sensitive electronics to the violence of the card production process.

In the prior art relating to the assembly of contact-type "smart cards", the electronics module is manufactured separately, and only implanted in finished singulated cards, during the final personalization process. Once in the cards the modules are typically programmed, magnetic stripe is programmed, and card embossed during the same stage of the process, which helps ensure that the personalized information is constant between all three of those media (magnetic stripe, embossing and chip). A further advantage achieved by this prior art process which is typical in today's card industry is that the sensitive electronics module is protected from the heat and pressure forces that comprise the lamination process for bank-type, (ISO 7810) compliant cards.

Those standard techniques for creating personalized contact-microprocessor cards have developed for compatibility with the standard card printing and lamination machines (such as Heidelberg machines) and personalization machines (such as the Datacard 9000) typically used in ISO 781x card production. Heidleberg printing presses are used for the offset printing of the

sheets, whereas the DataCard machines are used for the personalization of individual cards, which can include thermal or dye sublimation printing, embossing, magnetic stripe and microprocessor module programming.

The typical ISO 781x card production process also includes handling information, which must be kept highly secure, such as bank or credit card account information. That typical process also provides for the secure handling and shipment of graphical or branding elements that relate to the authenticity of the card as a transaction vehicle (such as bank association logo, watermarking, and bank card graphics), which are designed to foil counterfeiters.

But these known techniques are inconvenient for printing, manufacturing, and personalizing electronic bank-type cards with a volume of components greater than can fit into an ISO 7816 standard self-powered identification card module. Those diverse components can include transducers or other wireless IO components, displays, or batteries, solar panels or other power supplies, or even electronics for dynamically reforming the magnetic stripe. Many of those components cannot tolerate the relatively high temperatures, pressure and other forces required by those standard card assembly techniques. German patent No. DE 19645071, the disclosure of which is incorporated herein by reference, discloses a cold thermosetting adhesive (i.e., cool-lamination) method for fabricating cards with electronic components of diverse physical properties, and that method is embodied in "480" systems formerly offered for sale by Meinen-Zeigler & Co. of Munich Germany.

But those prior art techniques do not provide for the association of card or cardholder relevant data with electronic components in components embedded inside of cards after the cards are laminated. Neither does the prior art provide for the testing or programming of electronics already closed within finished cards.

SUMMARY OF THE INVENTION

An aspect of some embodiments of the present invention relates to a method of producing an identification card including embedded electrical elements. The method includes preparing a substrate including one or more electrical elements and laminating the substrate with one or more protective layers, for example PVC and/or plastic layers. In some embodiments of the invention, the lamination includes a hot lamination process and/or a controlled partially hot lamination process. Alternatively, the lamination includes a cold lamination process.

In some embodiments of the invention, the substrate includes durable electrical elements which are insensitive to hot lamination processes. Optionally, the electrical elements include a battery and/or a switch. Alternatively or additionally, the electrical elements include a processor chip and/or memory unit. Further alternatively or additionally, the electrical elements include thin/thick film resistors, integrated circuits, ceramic piezoelectric components, sonic/ultrasonic transducers, LCDs and/or LEDs.

In some embodiments of the invention, the substrate includes four, five or even six different electrical elements. For example, the substrate may carry a chip, a battery, two transducers and a switch. The different elements on the substrate may have different thickness. Optionally, an adhesive layer is placed between the substrate and the plastic layer in order to compensate for height variations.

In some embodiments of the invention, the elements are organized on the substrate in a manner which reduces the chances of damage during lamination, after lamination processing (e.g., embossing) and/or during use of the card. In an exemplary embodiment of the invention, electronic elements are placed towards edges and/or corners of the card, in order to reduce the chances of damage due to bending of the card by its owner.

In some embodiments of the invention, the lamination is performed using standard lamination machines known in the art for lamination of cards which do not include electrical elements during the lamination.

After the lamination, the production process may include adding customized graphics and/or holograms, embossing, microprocessor module implantation and/or other personalization techniques.

In some embodiments of the invention, the substrate includes at least one chip which is programmed and/or tested before the lamination. Optionally, the programming includes inserting data which is not related to a specific person. Personalized information is optionally added to the card only after the lamination is completed. Thus, the addition of the personalized information can be performed in a separate location from the lamination, for example, a highly secure location.

There is therefore provided in accordance with an embodiment of the invention, a method of manufacturing an identification card, comprising providing a substrate carrying a circuit including at least one electronic element and laminating the substrate to at least one isolating layer, using an at least partially hot lamination process, so as to form a card.

Optionally, the at least one electronic element comprises a battery. Optionally, the at least one electronic element comprises a transducer. Optionally, the transducer comprises an acoustic transducer. Optionally, the substrate carries at least four electronic elements. Optionally, the substrate carries a plurality of electronic elements and at least two of the elements have different thickness. Optionally, the at least one electronic element comprises a processor chip. Optionally, the at least one electronic element comprises a memory unit. Optionally, the method includes programming at least one element of the circuit before laminating the substrate to the at least one layer.

Optionally, programming the at least one element comprises storing one or more of a public ID, a private ID, a counter start point and at least one encryption key on the at least one element. Alternatively or additionally, programming the at least one element comprises generating one or more operator generated values, by applying an operator to a set of one or more random initial keys and one or more parameters, and programming the at least one element with the random initial keys and the one or more parameters.

Optionally, the one or more parameters comprise a public ID. Optionally, the one or more random initial keys include at least one of a private ID and a counter start point. Optionally, the one or more operator generated values comprise hash codes.

Optionally, the method includes initiating encryption of the random initial keys by the circuit. Optionally, the method includes transmitting the encrypted random initial keys by the circuit. Optionally, the method includes testing the transmitted encrypted random initial keys against a stored copy of the one or more operator generated values.

Optionally, the testing is performed before the laminating. Optionally, the testing is performed after the laminating. Optionally, testing the transmitted encrypted random initial keys comprises applying the operator to the encrypted initial keys and to the one or more parameters to obtain an actual value and comparing the actual value to a corresponding stored operator generated value. Optionally, the method includes repeating the applying of the operator and the comparing for substantially all the stored operator generated values. Optionally, the method includes testing the electronic element before laminating the substrate to the at least one layer. Optionally, laminating the substrate to the at least one layer comprises laminating to a plurality of layers.

Optionally, laminating the substrate to the at least one layer comprises laminating to at least one layer including printed graphics. Optionally, laminating the substrate to the at least

one layer comprises laminating to at least one transparent layer. Optionally, laminating the substrate to the at least one layer comprises laminating to at least one composite layer formed of a plurality of layers. Optionally, none of the layers included in the laminating, includes personal data.

Optionally, the method includes embossing the card after the lamination. Optionally, the method includes adding a hologram to the card after the lamination. Optionally, laminating the substrate to the at least one layer comprises laminating in a vacuum. Optionally, laminating the substrate to the at least one layer comprises laminating using an adhesive layer between the substrate and the isolating layer. Optionally, one or more of the at least one electronic elements is located near a corner of the substrate. Optionally, the one or more of the at least one electronic elements located near the corner comprises a battery or a chip.

Optionally, the one or more of the at least one electronic elements located near the corner comprises an element sensitive to bending.

Optionally, the isolating layer comprises a PVC layer, a plastic or a polymeric layer.

Optionally, the laminating comprises causing a change of state of at least one of the layers. Optionally, the laminating comprises filling air gaps between the substrate and the layers if such air gaps exist. Optionally, the method includes testing the substrate by applying a mechanical force to a sandwich formed of the substrate and one or more of the at least one isolating layer, before the laminating is performed. Optionally, the method includes attaching an activating switch to the card and connecting the activating switch to at least one component.

Optionally, the method includes attaching one or more data receiving or transmitting components to the card, and connecting the activating switch to at least one component. Optionally, the substrate has a thickness of less than 0.45 mm. Optionally, the card has a thickness of less than 0.84 mm. Optionally, laminating the substrate to the at least one isolating layer comprises laminating to an isolating layer having an area of at least the area of the substrate.

There is further provided in accordance with an embodiment of the invention, a method of manufacturing an identification card, comprising providing a substrate carrying a circuit including at least one electrical element, programming the circuit, and laminating the substrate with at least one isolating layer. Optionally, the at least one isolating layer has an area of at least the area of the substrate.

There is further provided in accordance with an embodiment of the invention, a method of manufacturing an identification card, comprising providing a circuit including at least one electronically programmable device, programming the at least one electronically programmable device; and inserting the programmed device into an identification card.

Optionally, inserting the programmed device into the card comprises laminating a substrate carrying the circuit with one or more plastic layers. Optionally, the laminating comprises using a cold lamination process. Optionally, the laminating comprises using an at least partially hot lamination process. Optionally, programming the device comprises programming with non-personalized data. Optionally, programming the device comprises programming with unique data which is different from information of other cards in a card batch of the card.

There is further provided in accordance with an embodiment of the invention, a method of preparing an identification card for use, comprising generating one or more random initial keys, providing one or more parameters, generating one or more operator generated values, by applying an operator to the one or more random initial keys and the one or more parameters, storing the one or more operator generated values, on a storage medium external to the card; and programming a circuit of the card with the random initial keys and the one or more parameters.

Optionally, the one or more parameters comprise a public ID of the card. Optionally, the one or more random initial keys include at least one of a private ID and a counter start point. Optionally, the one or more operator generated values comprise hash codes. Optionally, the method includes testing the card by comparing the operator generated values to values generated by the circuit. Possibly, the testing is performed before the circuit is embedded in the card with a plastic surrounding from all sides. Optionally, the one or more random initial keys are deleted from any storage medium not in the card after the storing of the one or more operator generated values and the programming of the circuit.

BRIEF DESCRIPTION OF FIGURES

Particular exemplary embodiments of the invention will be described with reference to the following description of embodiments in conjunction with the figures, wherein identical structures, elements or parts which appear in more than one figure are preferably labeled with a same or similar number in all the figures in which they appear, in which:

Figs. 1A-1D are schematic illustrations of identification cards, in accordance with some embodiments of the present invention;

Fig. 2 is a schematic illustration of layers of an identification card, in accordance with an embodiment of the present invention;

Figs. 3A-3C are schematic cross-section illustrations of transducers, in accordance with some embodiments of the present invention;

Fig. 4 is a block diagram of an identification card manufacture process, in accordance with an embodiment of the present invention; and

Fig. 5 is a block diagram of an identification card manufacture process, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Fig. 1A is a schematic illustration of a self-powered identification card 10, in accordance with an embodiment of the present invention. Identification card 10 comprises a substrate 17 (e.g., a Printed Circuit Board (PCB)) on which are mounted various electronic elements embedded within card 10. The elements mounted on substrate 17 optionally include a battery 11, a processor chip 12, transducers 14 and/or 15, and/or a switch 16. In some embodiments of the invention, a display unit (not shown), including for example an LCD and/or one or more LEDs, is also mounted onto substrate 17. Connectors 13 for an extended chip are optionally also provided.

In some embodiments of the invention, switch 16 (optionally an internal switch) enables the electronics in identification card 10 to first transmit data, which is then followed by a short receiving period. In other embodiments, of course, the single switch 16 permits multiple modes (as described in U.S. patent application 09/570,399 of the same applicant, the disclosure of which is incorporated herein by reference) where, for example, a single pressing of the switch indicates transmission and a double pressing indicates reception. In still other embodiments, multiple switches are provided on a single self-powered identification card. Typically, switch 16 is a dome switch constructed of stainless steel material, but of course it can be any other type of switch, for example, a membrane switch. A thin PVC layer optionally also covers the switch. According to an embodiment of the invention, switch 16 is provided on the side opposite the printed PVC layer where the actual magnetic stripe is placed.

In the embodiment of Fig. 1A, two transducers 14, 15 are provided, one for transmission (e.g., a speaker for acoustic signals) and the other for reception (e.g., a

microphone for acoustic signals). In other embodiments of the invention, only one transducer is used for both transmission and reception. Optionally, transducers 14 and/or 15 are piezo-ceramic discs positioned on top of a small brass/steel plate, as described hereinbelow with reference to Figs. 3A-3C. Alternatively or additionally, any other types of transducers may be used. In some embodiments of the invention, the self-powered identification card is thin (0.8 mm is a standard plastic card thickness), so that an internal microphone should also be very thin. The acoustic receiver can be any suitable microphone, such as a regular capsule microphone or an ultrasonic type microphone, which may be specific for a particular frequency or frequency range used. In some cases, special ultra-low power circuitry may be used, to allow for longer operation life of card 10. The acoustic transmitter can preferably generate a strong atmosphere wave. It is noted however, that only a small amount of power is required for short-range transmissions.

The reception transducer may be a capacitive microphone with two plates with a small air gap; that is, the distance between the two plates is small compared to conventional capacitive microphones. Any vibration on the plate changes the capacitance, which in turn changes the current to the reception circuitry. With a DC voltage applied across the plates, the resulting changing current signal is filtered, amplified, and then analyzed since the modulation of this signal is directly proportional to the information contained therein. The transmitted transducer is a thin stainless steel/brass plate on a PCB with a piezo-ceramic material on top of it. The distance between the top surface of the piezo-ceramic material and the printed PVC layer is approximately **0.8** microns (micro-meters).

In some embodiments of the invention, battery 11 is a thin-film battery or a thin button cell battery, as it known in the art. Furthermore, the use of Lithium-ION thin film or thin button batteries have desirable power characteristics, and Sodium-Ion technology allows for more convenient machining, and is less toxic.

Battery 11 is optionally small and operates in a range of between about 0-60 degrees Celsius, so that the battery will not be damaged even if the card is left inside a hot car. Alternatively, battery 11 operates and/or is not damaged in a larger range of temperatures, for example down to –15 degrees Celsius. Optionally, battery 11 has a life span for at least 10,000 card activations (i.e., switch pressings).

Chip 12 optionally includes a microprocessor and a memory unit although other chips may be used including specific dedicated hardware chips. Chip 12 optionally includes a digital

core (microprocessor and supporting circuits and components, such as memory unit) as well as an analog front end. Alternatively or additionally, chip 12 includes a Surface Mount Technology (SMT) component.

The electronic components in card 10, including battery 11, switch 16, chip 12 and/or the transducers, are optionally miniaturized and placed on select locations in the card to optimize the use of the limited space available. However, as components get smaller and smaller, the placement of some components (in whole or in part) should not affect the durability and reliability of the self-powered identification card.

In some embodiments of the invention, the electrical connection between battery 11 and the other components is soldered or otherwise securely attached and subsequently covered with PVC, making the circuitry very resilient robust and protected from environmental stresses and contaminants.

In addition to the above described electronic components, identification card 10 includes a magnetic strip and/or embossed data, including for example a name, a social security number and/or an expiration date. Alternatively or additionally, card 10 includes a bank logo, issuer graphics, a hologram and/or other security graphics and/or a photo of the cardholder.

In some embodiments of the invention, components in card 10 are placed in locations such that bending of the card will not damage or otherwise impair the functionality of the self-powered identification card. In addition, the electronic components are optionally placed in location which will allow the embossing of the data on card 10 and/or adding the hologram to the card, without causing damage to the electronic components.

In some embodiments of the invention, a region 18 is defined for the placement of embossing, holograms, a magnetic stripe and/or any other card additions which are to be added to card 10, in accordance with some embodiments of the invention, after the electronic components are added to the card. Optionally, within region 18, only electronic components insensitive to pressure and/or heat are placed, such as switch 16 and transducers 14 and 15. Alternatively, as described below region 18 does not include any electronic elements.

Fig. 1B is a schematic illustration of an identification card 10, in accordance with another embodiment of the present invention. In the embodiment of Fig. 1B, card 10 includes two batteries 11b and 15a. In addition, a single transducer 19 is shown instead of both of transducers 14 and 15. Chip 12, switch 16 and a protion of first battery 11a are located in a

magnetic stripe region 18a. In another embodiment, region 18b is the magnetic stripe area, instead of region 18a. In this embodiment, transducer 19 and part of second battery 11b are placed in region 18 without affecting the magnetic stripe.

Fig. 1C shows identification card 10, in accordance with still another embodiment of the present invention. In this embodiment, switch 16 is the only component in the magnetic stripe region 18a. According to this specific preferred embodiment of the invention the connectors 13 of self-powered identification card 10 are placed below transducer 14. The magnetic stripe region 18a can also be used for embossing purposes.

Fig. 1D shows identification card 10, in accordance with still another embodiment of the present invention. In the embodiment of Fig. 1D, a PCB substrate 19, smaller than substrate 17, is used to mount chip 12, tranducers 14 and 15 and switch 16. In some embodiments of the invention, a thin battery 11c is positioned near a corner of card 10, optionally adjacent substrate 19. Positioning battery 11c near the edges, optionally the corners, of card 10, reduces the chances that the battery will be damadged due to bending of card 10. Alternatively or additionally, other elements of card 10, such as chip 12, are located near the edges and/or corners of card 10.

Due to the fact that the attached components are relatively minimized, there is an entire area 18d for embossing on the self-powered identification card 10, which is free of components. The doted Section 60 represents an optional area for hologram adhesive.

The attachment of the Hologram over circuit elements such as batteries requires the modification of certain process parameters. Holograms are typically "hot stamped" onto the card body. This involves a heated "ram" that literally melts the plastic of the hologram into and onto the card body in the desired location. The presence of a battery or other circuit element directly below the hologram prevents the plastic of the card body from reaching the required temperature for conventional hot stamping. In order to achieve the required adhesive of hologram to the card, there is a need to use a state of the art machines that permit a controlled temperature profile (specific temperatures from specific times) that will permit the fusing of the card body plastic to the hologram plastic.

As the four embodiments of Figs. 1A to 1D illustrate, the placement of the components in self-powered identification card 10 is an important design criterion. Generally, the embossing area, which is also typically not the same area as the magnetic stripe region 18, should contain no components as the process of embossing may destroy or damage

components, as shown in Fig. 1D. Furthermore, both the embossing area 18d and the area applied for the connecting of smart chip module 13 are free from components of self-powered identification card 10. This allows embossing to be accomplished with relative ease, while minimizing the concerns that credit card manufacturers may have on whether the embossing process might harm an electronic component.

Fig. 2 is a schematic illustration of the layers of identification card 10, in accordance with an embodiment of the present invention. The electronic elements to be embedded in card 10, for example chip 12, battery 11, transducer 14, and switch 16, are placed on a substrate layer 23. Optionally, an insulation material (not shown), for example PVC, is used to cover battery 11 and/or other electronic components which require insulation. In some embodiments of the invention, an epoxy material and/or any other reinforcement material is placed on some or all of the electronic components in order to prevent moisture from forming and/or to prevent damage from physical bending.

In some embodiments of the invention, substrate layer 23 comprises a very thin PCB whose underside (in the direction facing substrate 25) has copper interconnects with special coating. Optionally, a filler material is used to cover substrate layer 23 along with the embedded electronic components in order to cover gaps and/or to even out the height of layer 23.

A printed PVC layer 22 is optionally placed above substrate layer 23. A magnetic stripe is fabricated on PVC layer 22. Analogously, a printed PVC layer 25 is optionally provided below layer 23. Various images (e.g., credit card logo, and bank logo), photos, and other information associated with credit cards are optionally provided on PVC layer 25. Conversely, the magnetic stripe can be placed on printed PVC layer 25 and the other images and photos can be placed on PVC layer 22. Clear PVC outer layers 21 and 26 are optionally provided on the outer surface of each side of identification card 10.

In some embodiments of the invention, layers 21, 22, 23, 25 aand 26 are combined in a lamination process. Optionally, a hot lamination process is used. In accordance with this option, the electronic components of substrate 23 are optionally durable components known in the art which are not sensitive to temparetures and/or pressures required in hot lamination processes. Existing durable components can undergo lamination and embossing at 120 degrees for 10 minutes. Alternatively, a controlled, partially hot, lamination process is used. Further alternatively, a cold lamination process is used, such as described in the above mentioned DE

19645071 patent. Further alternatively or additionally, a shielding layer is placed on relatively sensative components before the lamination to prevent damage due to the lamination process.

In the lamination process, an "Activation energy" (any type of energy that causes materials or adhesives to change state) is generally used. If an "Activation energy" other than thermal energy is used, for example as in cold lamination, less insensitive elements may be used. Optionally, the lamination includes using an adhesive material that serves as both an adhesive and a filler, which is required to protect the electronic layer against normal forces.

The mechanical construction of transducers 14 and/or 15 will now be described with reference to Figs. 3A to 3C. Fig. 3A shows a cross-section of a circular transducer, such as transducer 14 of Fig. 1A, in accordance with one embodiment of the present invention.

On PCB 35 (corresponding to substrate 23 of Fig. 2 and substrates 17 and 19 of Figs. 1A-1D), a brass/stainless steel plate 34 is optionally provided. A small piezo-ceramic disc or element 33 is optionally placed on top of brass/stainless steel plate 34. In order to provide some room for the vibration and/or movement of piezo-ceramic element 33, needed to generate acoustic signals, some space is provided around the piezo-ceramic element 33.

The resonant frequency of the acoustic signals generated by the transducer depends on the selection of the various parameters of the components in the transducer. These parameters include, for example, the thickness of the piezo-ceramic element 33, and the thickness, stiffness, type of material, shape, and diameter of the brass/stainless steel plate 34.

In some embodiments of the invention, printed PVC layer 30 (corresponding to PVC layer 22) is spaced apart from piezo-ceramic element 33. The distance from the top of the piezo-ceramic element 33 to the bottom of the printed PVC layer 30 forms a reverberation chamber 31. Walls 32 defining the sides of chamber 31 are optionally formed of an intermediate adhesive and/or a plastic layer, as is known in the art. The acoustic signal generated by the transducer is generally directed toward PCB 35 (downward direction on Fig. 3A).

In an exemplary embodiment of the invention, PCB 35 has a thickness of approximately 100 μm (microns), brass/stainless steel plate 34 has a thickness of approximately 100-150 μm, piezo-ceramic element 33 has a thickness of approximately 150 μm and chamber 31 has a thickness of approximately 80 μm.

Fig. 3B shows an alternative embodiment of the transducer construction. In this embodiment, brass/stainless steel plate 34 is not used. Instead, piezo-ceramic element 33 rests

on, and uses PCB layer 35, as a substitute plate. In some embodiments of the invention, a portion of printed PVC layer 30 protrudes into chamber 31 so that the distance between the top of the piezo-ceramic element 33 and the bottom of the protruded printed PVC layer 30 remains at about 80 μm. In a variation of this embodiment, piezo-ceramic element 33 is made thicker and the protruding portion of the printed PVC layer 30 is not used. The additional thickness of the piezo-ceramic element 33 would be approximately 100-150 μm (or the thickness of the brass/stainless steel plate 34, had such a plate been used). Thus, the distance between the top of the piezo-ceramic element 33 and the bottom of the unprotruding printed PVC layer 30 is 80 μm.

The embodiments of Figs. 3A and 3B show transducers, which are fabricated during the fabrication of card 10. In contrast, Fig. 3C shows a third embodiment of the transducer construction, where the transducer is modular and not fabricated with card 10. In this embodiment, chamber 31 is defined by a wall 36 and a cover portion 36a. In one preferred embodiment, cover portion 36a and wall 36 are made either of steel or of plastic. In this configuration, the piezo-ceramic element 33 need not rely on the printed PVC layer 30 to form chamber 31. It is noted that the modular transducer of Fig. 3C is better suited, in some cases, for use in hot lamination processes.

Fig. 4 schematically illustrates in block diagram form a manufacturing process of self-powered identification card 10, in accordance with an embodiment of the present invention. The process of Fig. 4 may be divided into three stages which may be performed in different geographical locations and/or at different times. It is noted, however, that the process may be performed in more or fewer stages, and the stage division of Fig. 4 is brought only by way of example.

In a first stage, referred to as module assembly 41, a module including substrate 17 (Fig. 1A, for example, substrate layer 23 in Fig. 2) and the electronic components thereon, is assembled. In a second stage, card 10 is assembled. Stage 42 includes programming the module assembled during module assembly 41, in an act referred to as Writing Module 422. In addition, a hash generation process 423 is performed. The results of the hash generation 423 are optionally stored in a hash database (DB) 46 in addition to their use in programming the module. Stage 42 further comprises manufacturing of the layers of card 10 described in Fig. 2 and the graphics to be imprinted on card 10, such as a bank logo, a hologram and/or a magnetic stripe (421).

The programmed module and layers of card 10 are then assembled (424) into card 10, for example as described above with reference to Fig. 2. In some embodiments of the invention, the assembly includes printing card graphics on PVC layers 22 and 25. In some embodiments of the invention, the card graphics are printed on PVC layers 22 and/or 25 before they are combined with substrate layer 23. Alternatively or additionally, in order to perform the printing on a card with a suitable thickness for some printing machines, the printing is performed after PVC layers 22 and 25 are combined to substrate layer 23. Optionally, the combined layers 22, 23 and 25 are inserted to a printing machine twice so as to print on both sides of the card. After the printing, clear outer layers 21 and 26 are optionally laminated, or otherwise attached, to the other layers so as to form card 10. Clear overlay layers 21 and 26 make the plastic surface of card 10 more durable. Optionally, clear outer layers 21 and 26 are attached to PVC layers 22 and 25, respectively, before their attachment to substrate layer 23. Alternatively, clear outer layers 21 and 26 are attached to PVC layers 22 and 25, respectively, after the PVC layers are attached to substrate 23.

In some embodiments of the invention, clear outer layers 21 and 26 include a magnetic strip and/or a security fluorescent printing. Alternatively or additionally, the magnetic strip and/or the fluorescent printing are added to the card after the card is assembled. In some embodiments of the invention, after the layers are all combined an additional chip (additional to the components of substrate 17) is added to card 10 using methods known in the art.

By the end of stage 42, the card 10 is in its final form as an ISO standard bank-type card, complete with magnetic stripe, signature panel, hologram, graphics, and bank association logo. Finally, self-powered identification card 10 emerges from this stage singulated (i.e., separated from the sheet into single cards) with the magnetic stripe and the unprogrammed smart chip, and not yet affiliated with any cardholder account information. By having the card reach this stage without including any personal information, the security measures required in storing and transporting personal cards are not required until after the second stage.

The last stage of the manufacturing of self-powered identification card 10 is a Personalization stage 43. In the personalization stage 43, the physical card is linked to its owner. Stage 43 includes the same personalization process as with any standard credit card, with or without self-powered identification card functionality. Stage 43 includes embossing, unique graphic printing, magnetic stripe writing, and/or self-powered identification card programming. In stage 43, the magnetic stripe and the optional smart chip are programmed,

and associated with an actual card holder account, such as personalized self-powered identification card 45, which is the final product of the self-powered identification card 10 manufacturing process.

If required, a picture or a signature of the cardholder can be added, at stage 43, to the graphics of self-powered identification card 10. After stage 43, self-powered identification card 10 is ready for shipment to the cardholder.

In addition to the above, the self-powered identification card is optionally squeezed (i.e., activated), sending a signal that generates a link table 44, which links the ID of the self-powered identification card manufacturer and the personalized credit card ID of the card holder.

Stage 42, is a distinct stage of the manufacturing process than stage 41. Such that stage 42 can be carried out at a facility other than that used (i) to print and laminate printed PVC layers 22 and 25 with clear PVC layers 21 and 26 (PVC Assembly Stage 421); and (ii) module assembly stage 41. Therefore Stage 42 is module that can be collocated either within the same facility used for within the same facility as PVC Assembly Stage 421 or Personalization Stage 43.

Proprietors of credit card brands (each an "Issuing Group"), such as bank card associations (e.g. Visa or Mastercard) or stand-alone brands (e.g. American Express, Discover, JCB, Diners), along with bank and credit card issuers (e.g. Nippon Shinpan, Citibank, Chase, First USA, Barklays, HSBC) maintain rigorous quality and security requirements for the facilities used to produce their cards. Those requirements are aimed to protect the cardholder account information used in personalizing the cards, and to protect the graphical and other security elements used to prevent the production of counterfeit cards.

When a card under the present invention is intended as a card to be issued as a payment card to one of those groups, the PVC layers 21, 22, 25 and 26 contain such controlled elements such as bank and bank association graphics. Typically, under the rules those groups maintain, those PVC layers should be printed within facilities that are certified by those groups for their safety, security and quality.

Similarly, since the Personalization Stage 43 entails accessing sensitive cardholder account information, those groups also typically require that Personalization Stage 43 also take place within facilities that are certified by those groups for their safety, security and quality.

Normally, PVC Assembly Stage 421 occurs in printing machine lines that are distinct from the Datacard 9000-type machine lines used in Personalization Stage 43. Card Assembly Stage 42 under the present invention can occur at separate facilities, or within the same facilities as PVC Assembly Stage 421, or Personalization Stage 43. As indicated in Figure 4, Card Assembly Stage 42 shares a facility PVC Assembly Stage 421, thus saving the expense of having a separate facility certified by the Issuing Groups. Once assembled, the pre-personalized cards can be shipped using secure shipping techniques. In that way, a single Card Assembly Stage 42 can serve several personalization facilities. Maximally, Card Assembly Stage 42, PVC Assembly Stage 421, and Personalization Stage 43 would all be housed within a single facility, certified by at least one Issuing Group. Minimally, each of Card Assembly Stage 42, PVC Assembly Stage 421, and Personalization Stage 43 would each be housed within separate facilities, each being certified by at least one Issuing Group.

Fig. 5 schematically illustrates the manufacturing process and the testing of self-powered identification card 10 according to an embodiment of the invention. At the first stage, 41, a self-powered identification card module 51 is manufactured, comprising the components and PCB of self-powered identification card 10, as described with reference to Figs. 1A-1D and/or Fig. 4. In the second stage 42, a Module Writing 422 programs all data required into memory units of self-powered identification card module 51. According to some embodiments of the invention, the memory units are integrated parts of chip 12. In an exemplary embodiment of the invention, the required programmed data that is stored in module 51 includes:

- Card Public ID – an individual ID that each self-powered identification card is assigned during its manufacturing process. The individual ID is essentially the card's serial number and is unique to that card. The manufacturer's server has data concerning each self-powered identification card public ID.
- Card Private ID - a random value that is generated per card from a random number generating machine, as an additional card ID. While the manufacturer server knows each self-powered identification card public ID, it does not know or have access to the self-powered identification card private ID. This random value is a secret number, and is used to increase the security level of self-powered identification card.
- Counter Start – a random value that represents the initial self-powered identification card counter value, where each self-powered identification card has random

initial card counter. Each squeeze on the self-powered identification card switch will raise the value of the self-powered identification card counter by a predetermined value (e.g., value = 1).

- Encryption Keys – one or more random values that are used for the encryption of the Private Card ID and the counter value while they will be transmitted from the self-powered identification card. According to one embodiment of the invention the encryption that is used by the card, in order to encrypt the Private ID and the counter, is Triple Data Encryption Standard (3-DES), but of course, any other encryption method can be used, in order to encrypt the Private ID and the counter.

It is noted that the above data is brought by way of example and that any other data set may be used, including data sets for transmission of non-encrypted data.

Random Generator 52 provides the random values (i.e., secret keys) that represent the Card Private ID, the Counter Start and the two encryption keys. Module Writing 422 stores these secret generated keys in the memory units of Module 51. The programming station, Module Writing 422, inserts the actual self-powered identification card specific data into the card (i.e., into module 51) such as, card software, card secret data (i.e., Card Private ID, Counter Start and the two encryption key) and Card Public ID. As a result, from the programming process a Programmed Module 53 is generated, which can now transmit authentication codes.

The same random and encrypted values used to program a specific self-powered identification card are also used to generate a Hash table for that specific card..The Hash table is built from N number results of a hash function (i.e., a one-way mathematical function). Hash table is used to allow a server to identify a user and according to its self-powered identification card.

A Hash function is a transformation that converts a string of any size to a fixed-size string. The fixed-size string is called Hash value. Hash functions with this property have a variety of general computational uses, but when employed in cryptography, the hash functions are usually chosen to possess additional properties. The basic requirements for a cryptographic hash function are as follows: the input can be of any length; the output has a fixed length; the computational effort is relatively moderate; the output is one-way (i.e. it is not possible to determine the input from a knowledge of the output); and the output is collision-free (i.e. it is

not possible to find any two messages x and y such that their Hash functions H fulfil the equation: H(x) = H(y)).

Hash Generator 423 generates a cryptographic value corresponds to an encryption process such as, a hash function. Hash Generator 423 receives at its input a Card Private ID value, a current counter value and the encryption keys. Hash Generator 423 uses the encryption key(s) to encrypt the Private ID and the current counter, by an encryption function (e.g., T-DES). The encrypted data together with set of predetermined parameter are used to provide the output of Hash Generator 423. The provided output is an addition encrypted value, which is stored as a part of the Hash table in an external Hash Database 46. The initialization data provided by Random Generator 52 and the predetermined set of parameters are now used to generate additional N hash function values for N future squeezes on the self-powered identification card switch, and thereby creating a hash table that is stored in the external hash database. These values that are stored in the hash table are referred to as operator generated values. For each future squeeze, a hash function is operated using the Card Public ID as the key to identify the cardholder and compare it with its operator generated values. After the hash table was filled with all N values of future squeezes, the values of the private ID and the encryption keys are deleted.

The programming module 53 initiates the process of creating the authentication database 46 for specific card (i.e., hash table) only after successful programming of module 53. At that point, according to a preferred embodiment of the invention, the programming module 422 sends the card data to an authentication database creator. The authentication database creator builds the authentication database (i.e., hash table) and stores it in the authentication database 46, waiting for the self-powered identification card to be exported from the facility, which will define the actual authentication database which will be retrieved.

Once the programming is finished and the memory unit is filled completely, a Testing Station 54 checks the programming of Programmed Module 53, in order to define whether it was programmed properly.

At the testing station 54, the programmed module 53 is tested against its own hash table, which is stored in hash database 46, to check if it transmits the information that is stored in it, or generated by it, correctly. Testing station 54 squeezes the switch (i.e., press a button), which is physically attached to module 51, to generate a signal and transmit it, in order to compare it to its own hash table. The transmitted signal then goes through the same hash

function, as used to generate its own hash table, and two bit streams are compared. This is done in order to define whether the programming of module 51 was successful.

Testing Station 54 tests Programmed Module 53 before it is assembled. In case the programmed module 53 does not pass the test, there is an option to save the resources of Card Public ID by recycling the Card Public ID from Programmed Module 53, and making its value available for use with another self-powered identification card. All the other data were generated at random, so that there is no need to save or remember them. The programmed module is destroyed and its hash table is not used or is deleted.

If the test passes, then the status of the programmed module 53 changed to a working module 55. Card Assembly Process 424 laminates working module 55 with plastic and graphics 421. The card assembly process optionally includes laminating the following card layers:

- Electronic module layer (i.e., working module 55).
- Two plastic layers on each side of the electronic module layer.
- Adhesive layer between the front plastic and the electronic module layer and between the back plastic and electronic layer.

The details of the different layers have been described with reference to Fig. 2.

If an optional smart chip module is to be added, then it is added following the end of the lamination process.

In order to prevent the generation of air bubbles or swelling, the bonding process of the layers is made in a vacuum (as disclosed for example, in DE 19645071), and optionally also using rugged surfaces that are pressed against each other.

After the Card Assembly Process 424 is finished, an assembled Self-powered identification card 57 is provided in its final form as an ISO standard card, shaped with graphics, and may have an optional magnetic stripe and/or smart module, as described also with reference to Fig. 4.

At this stage of the manufacturing process, Testing Station 56 tests the assembled Self-powered identification card 57. This test has almost the same functionality as the test that was taken by Testing Station 54, but at this testing 56 the card is already assembled. The assembled self-powered identification card 57 transmits data to Testing Station 56, which checks whether the assembled Self-powered identification card 57 has beeped, and if another beeping is raising the inner counter of Self-powered identification card 57 by a wanted value.

In order to perform the tests of stations 54, 56 (i.e., transmitting data from the card), the switch on the self-powered identification card needs to be squeezed. According to one embodiment, a plunger is attached to the card where its operation squeezes on the card's switch.

The last stage of the manufacturing process of Self-powered identification card 57 is the Personalization stage 43 that was described with reference to Fig. 4.

According to some embodiments of the invention, in order to activate the card automatically, the card public ID or any other identification information is being recorded on the magnetic stripe and it is being read during personalization stage 43. The read information from the magnetic stripe cause for a link to be created between the cardholder and that specific self-powered identification card.

To activate and personalize the assembled self-powered identification card 57, the user normally has to log into the card distributor's website and press the button (i.e., switch) on the assembled self-powered identification card 57. The website then processes the data transmission and affiliates the card ID with the user's account. In fact, the self-powered identification card can emit a signal usable over ordinary phone lines or cellular phones and thus, the cardholder's first activation of a card could also result in affiliating the card ID with the cardholder's account. Thus, the issuer needs not worry about programming the self-powered identification card, since the affiliation of the self-powered identification card with the user's account occurs at the back-end, after the user has activated the self-powered identification card by pressing the self-powered identification card button. The personalization of the self-powered identification card occurs upon the "first use" of the self-powered identification card in accordance with one embodiment of the present invention. In contrast, conventional technologies require some form of card-accepting device to be available and operational at the time of card registration or activation in order for personalization to occur.

An additional test is also typically carried out for the Self-powered identification card button, which is a mechanical test, and which tests if the switch is working according to the standard requirement. A plunger is used to execute the test for the switch.

With respect to the mechanical construction of the self-powered identification card, the self-powered identification card optionally complies with the credit card set of standards – ISO 7810, 7811-1 to 7811-6, 7813, 7816-1, and 7816-2. Some minor deviations from the standard may be required, for example the location of the external switch and/or the additional

functionality provided by the self-powered identification card electronics. In other embodiments, no attempt is made to make the self-powered identification card comply with a specific credit card standard.

Card 10 optionally allows for conventional embossing in an area (for example region 18 of Fig. 1) reserved for embossing cardholder information in compliance with ISO 7816. High pressure embossing is optionally also performed in a card signature field of card 10. In some embodiments of the invention, no electronic elements which are sensitive to embossing are included in these areas.

Branding is also important for self-powered identification card sponsors. Card 10 is optionally printed with external features of an integrator's choice, such as holograms and/or company logos.

The present invention includes many attributes which provide improvement over existing identification card manufacturing procedures. For example, the manufacturer programs the card with appropriate values, i.e., codes and IDs, as required for a predetermined purpose. In some embodiments of the invention, the cards are produced in sheets, which facilitates significant productivity efficiency over the handling of individual self-powered identification cards.

Furthermore, according to the credit card standards, if self-powered identification card modules are exposed, the self-powered identification card should comply with the credit card standards organization's approved payment system. This involves the need for additional components in the cards, and additional programming to comply with the payment standard. By not exposing the modules in the self-powered identification cards of the present invention, the manufacturer of these self-powered identification cards need not comply with this payment system standard. This allows the manufacturer to save on the cost of supplying, assembling, and programming the chips with the payment system standard-complying logic.

Various hardware and software elements and/or methods described above may be performed using elements and/or methods described in one or more of the following patent applications, 60/278,010, filed March 22, 2001 09/853,017, filed May 10, 2001 60/278,065, filed March 22, 2001 60/277,996, filed March 22, 2001 US patent application filed May 12, 2000, attorney docket 20257-11, by applicants Alon Atsmon, et al., and entitled "Physical Presence digital Authentication System", PCT/IL99/00506 filed on 16-Sep-99, PCT/IL99/00525 filed on 04-Oct-99, PCT/IL99/00521 filed on 01-Oct-99, PCT/IB99/02110,

filed on 16-Nov-99, PCT/IL01/00758 filed on 14-Aug-01, 09/820,358 filed March 28, 2001, PCT/IL98/00450 filed on 16-Sep-98 and a PCT application filed on even date by applicant Comsense, et al. and having attorney docket 100/02658, the disclosures of which are incorporated herein by reference.

It will be appreciated that the above described methods may be varied in many ways, including, changing the order of steps, and/or performing a plurality of steps concurrently. It should also be appreciated that the above described description of methods and apparatus are to be interpreted as including apparatus for carrying out the methods and methods of using the apparatus.

The present invention has been described using non-limiting detailed descriptions of embodiments thereof that are provided by way of example and are not intended to limit the scope of the invention. It should be understood that features and/or steps described with respect to one embodiment may be used with other embodiments and that not all embodiments of the invention have all of the features and/or steps shown in a particular figure or described with respect to one of the embodiments. Variations of embodiments described will occur to persons of the art.

It is noted that some of the above described embodiments may describe the best mode contemplated by the inventors and therefore may include structure, acts or details of structures and acts that may not be essential to the invention and which are described as examples. Structure and acts described herein are replaceable by equivalents which perform the same function, even if the structure or acts are different, as known in the art. Therefore, the scope of the invention is limited only by the elements and limitations as used in the claims. When used in the following claims, the terms "comprise", "include", "have" and their conjugates mean "including but not limited to".

CLAIMS

1. A method of manufacturing an identification card, comprising:
providing a substrate carrying a circuit including at least one electronic element; and
laminating the substrate to at least one isolating layer, using an at least partially hot lamination process, so as to form a card.

2. A method according to claim 1, wherein the at least one electronic element comprises a battery.

3. A method according to claim 1, wherein the at least one electronic element comprises a transducer.

4. A method according to claim 3, wherein the transducer comprises an acoustic transducer.

5. A method according to claim 1, wherein the substrate carries at least four electronic elements.

6. A method according to claim 1, wherein the substrate carries a plurality of electronic elements and at least two of the elements have different thickness.

7. A method according to claim 1, wherein the at least one electronic element comprises a processor chip.

8. A method according to claim 1, wherein the at least one electronic element comprises a memory unit.

9. A method according to claim 1, comprising programming at least one element of the circuit before laminating the substrate to the at least one layer.

10. A method according to claim 9, wherein programming the at least one element comprises storing one or more of a public ID, a private ID, a counter start point and at least one encryption key on the at least one element.

11. A method according to claim 9, wherein programming the at least one element comprises generating one or more operator generated values, by applying an operator to a set of one or more random initial keys and one or more parameters, and programming the at least one element with the random initial keys and the one or more parameters.

12. A method according to claim 11, wherein the one or more parameters comprise a public ID.

13. A method according to claim 11, wherein the one or more random initial keys include at least one of a private ID and a counter start point.

14. A method according to claim 11, wherein the one or more operator generated values comprise hash codes.

15. A method according to claim 11, comprising initiating encryption of the random initial keys by the circuit.

16. A method according to claim 15, comprising transmitting the encrypted random initial keys by the circuit.

17. A method according to claim 16, comprising testing the transmitted encrypted random initial keys against a stored copy of the one or more operator generated values.

18. A method according to claim 17, wherein the testing is performed before the laminating.

19. A method according to claim 17, wherein the testing is performed after the laminating.

20. A method according to claim 17, wherein testing the transmitted encrypted random initial keys comprises applying the operator to the encrypted initial keys and to the one or more parameters to obtain an actual value and comparing the actual value to a corresponding stored operator generated value.

21. A method according to claim 20, comprising repeating the applying of the operator and the comparing for substantially all the stored operator generated values.

22. A method according to claim 1, comprising testing the electronic element before laminating the substrate to the at least one layer.

23. A method according to claim 1, wherein laminating the substrate to the at least one layer comprises laminating to a plurality of layers.

24. A method according to claim 1, wherein laminating the substrate to the at least one layer comprises laminating to at least one layer including printed graphics.

25. A method according to claim 1, wherein laminating the substrate to the at least one layer comprises laminating to at least one transparent layer.

26. A method according to claim 1, wherein laminating the substrate to the at least one layer comprises laminating to at least one composite layer formed of a plurality of layers.

27. A method according to claim 1, wherein none of the layers included in the laminating, includes personal data.

28. A method according to claim 1, comprising embossing the card after the lamination.

29. A method according to claim 1, comprising adding a hologram to the card after the lamination.

30. A method according to claim 1, wherein laminating the substrate to the at least one layer comprises laminating in a vacuum.

31. A method according to claim 1, wherein laminating the substrate to the at least one layer comprises laminating using an adhesive layer between the substrate and the isolating layer.

32. A method according to claim 1, wherein one or more of the at least one electronic elements is located near a corner of the substrate.

33. A method according to claim 32, wherein the one or more of the at least one electronic elements located near the corner comprises a battery or a chip.

34. A method according to claim 32, wherein the one or more of the at least one electronic elements located near the corner comprises an element sensitive to bending.

35. A method according to claim 1, wherein the isolating layer comprises a PVC layer.

36. A method according to claim 1, wherein the isolating layer comprises a plastic or polymeric layer.

37. A method according to claim 1, wherein the laminating comprises causing a change of state of at least one of the layers.

38. A method according to claim 1, wherein the laminating comprises filling air gaps between the substrate and the layers if such air gaps exist.

39. A method according to claim 1, comprising testing the substrate by applying a mechanical force to a sandwich formed of the substrate and one or more of the at least one isolating layer, before the laminating is performed.

40. A method according to claim 1, comprising attaching an activating switch to the card and connecting the activating switch to at least one component.

41. A method according to claim 40, comprising attaching one or more data receiving or transmitting components to the card, and connecting the activating switch to at least one component.

42. A method according to claim 1, wherein the substrate has a thickness of less than 0.45 mm.

43. A method according to claim 1, wherein the card has a thickness of less than 0.84 mm.

44. A method according to claim 1, wherein laminating the substrate to the at least one isolating layer comprises laminating to an isolating layer having an area of at least the area of the substrate.

45. A method of manufacturing an identification card, comprising:
providing a substrate carrying a circuit including at least one electrical element;
programming the circuit; and
laminating the substrate with at least one isolating layer.

46. A method according to claim 45, wherein the at least one isolating layer has an area of at least the area of the substrate.

47. A method of manufacturing an identification card, comprising:
providing a circuit including at least one electronically programmable device;
programming the at least one electronically programmable device; and
inserting the programmed device into an identification card.

48. A method according to claim 47, wherein inserting the programmed device into the card comprises laminating a substrate carrying the circuit with one or more plastic layers.

49. A method according to claim 48, wherein laminating comprises using a cold lamination process.

50. A method according to claim 48, wherein laminating comprises using an at least partially hot lamination process.

51. A method according to claim 47, wherein programming the device comprises programming with non-personalized data.

52. A method according to claim 47, wherein programming the device comprises programming with unique data which is different from information of other cards in a card batch of the card.

53. A method of preparing an identification card for use, comprising:

generating one or more random initial keys;

providing one or more parameters;

generating one or more operator generated values, by applying an operator to the one or more random initial keys and the one or more parameters;

storing the one or more operator generated values, on a storage medium external to the card; and

programming a circuit of the card with the random initial keys and the one or more parameters.

54. A method according to claim 53, wherein the one or more parameters comprise a public ID of the card.

55. A method according to claim 53, wherein the one or more random initial keys include at least one of a private ID and a counter start point.

56. A method according to claim 53, wherein the one or more operator generated values comprise hash codes.

57. A method according to claim 53, comprising testing the card by comparing the operator generated values to values generated by the circuit.

58. A method according to claim 57, wherein the testing is performed before the circuit is embedded in the card with a plastic surrounding from all sides.

59. A method according to claim 53, wherein the one or more random initial keys are deleted from any storage medium not in the card after the storing of the one or more operator generated values and the programming of the circuit.

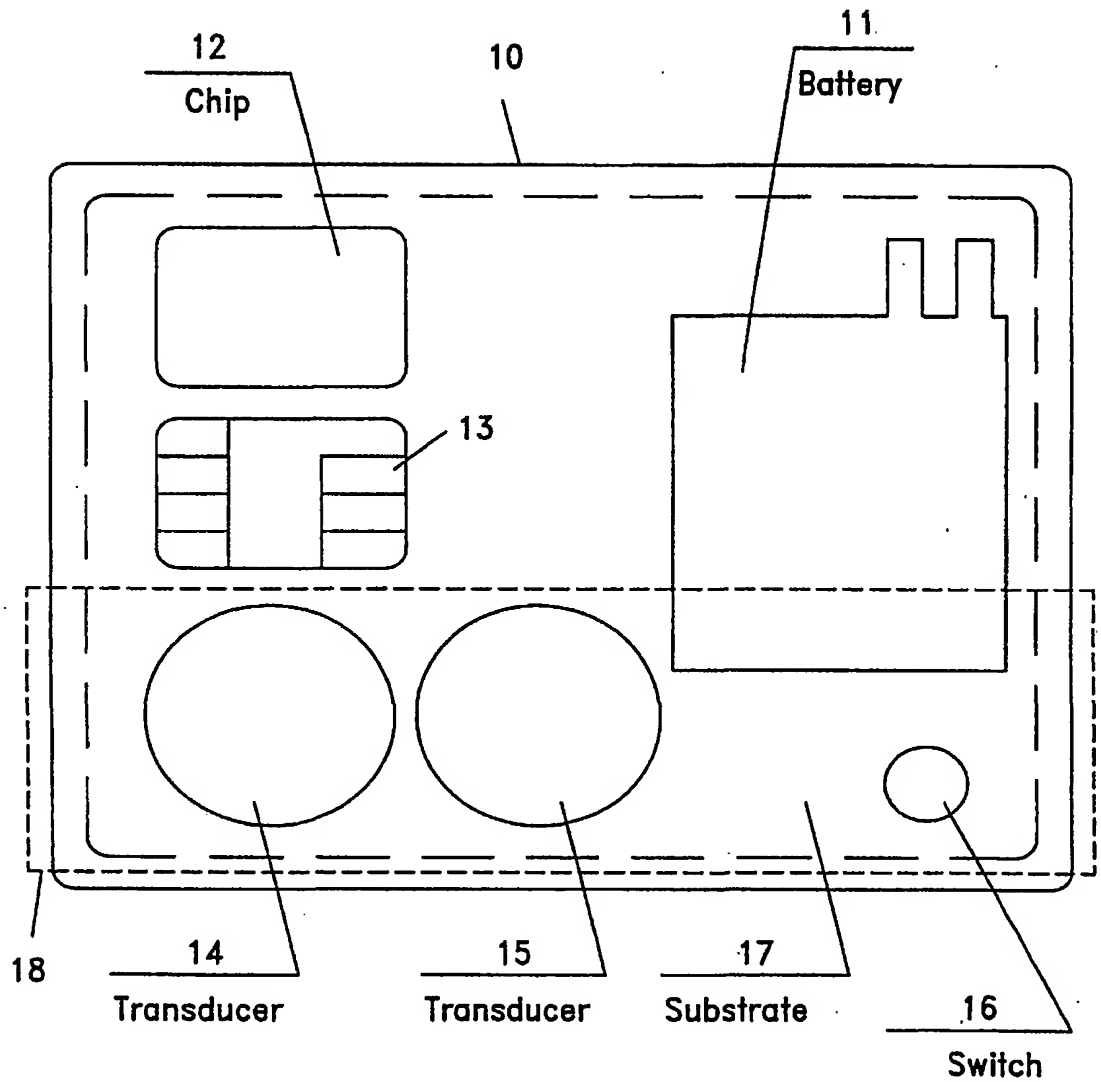

12
Chip
10
11
Battery
13
18
14
Transducer
15
Transducer
17
Substrate
16
Switch

Fig. 1A

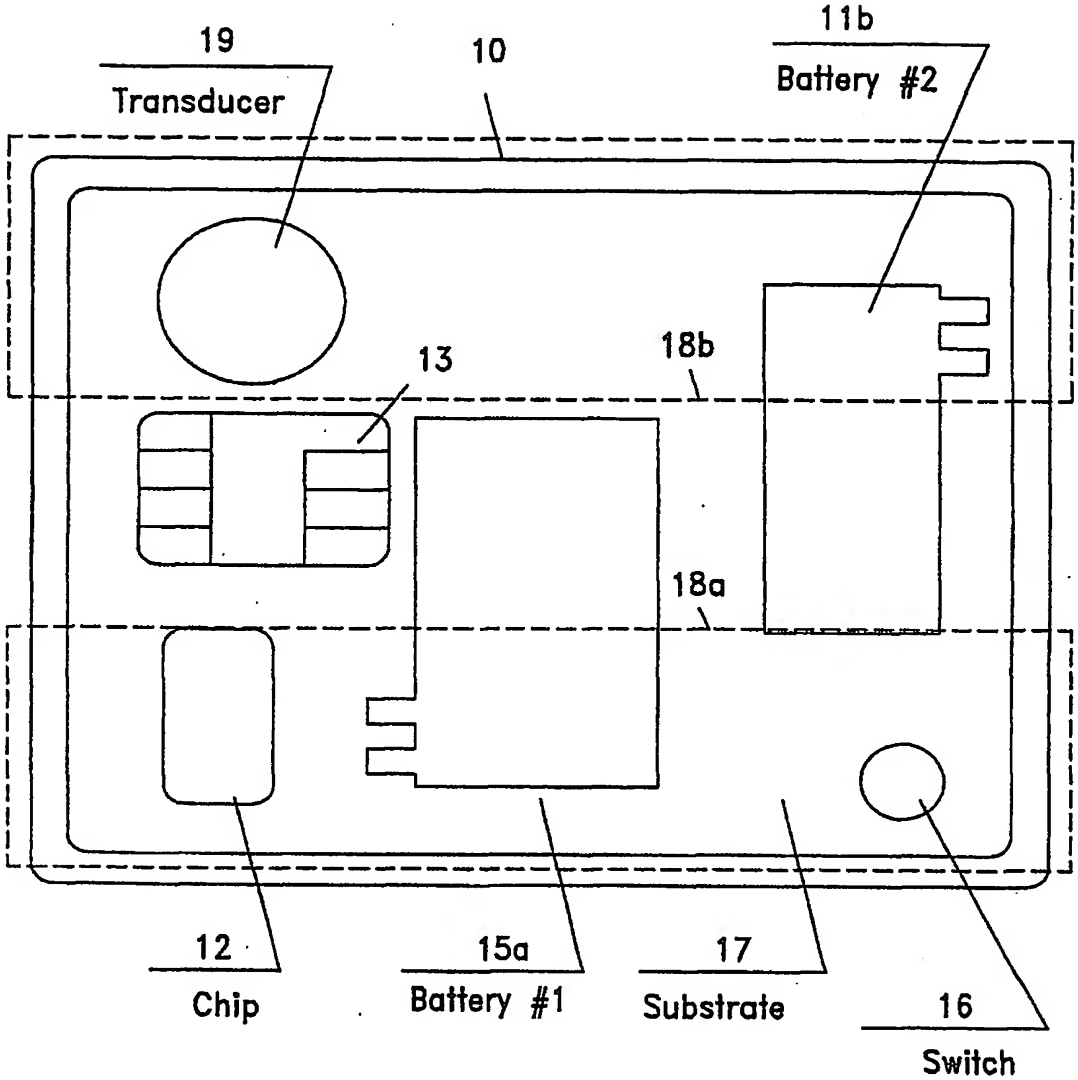

19
Transducer
10
11b
Battery #2
13
18b
18a
12
Chip
15a
Battery #1
17
Substrate
16
Switch

Fig. 1B

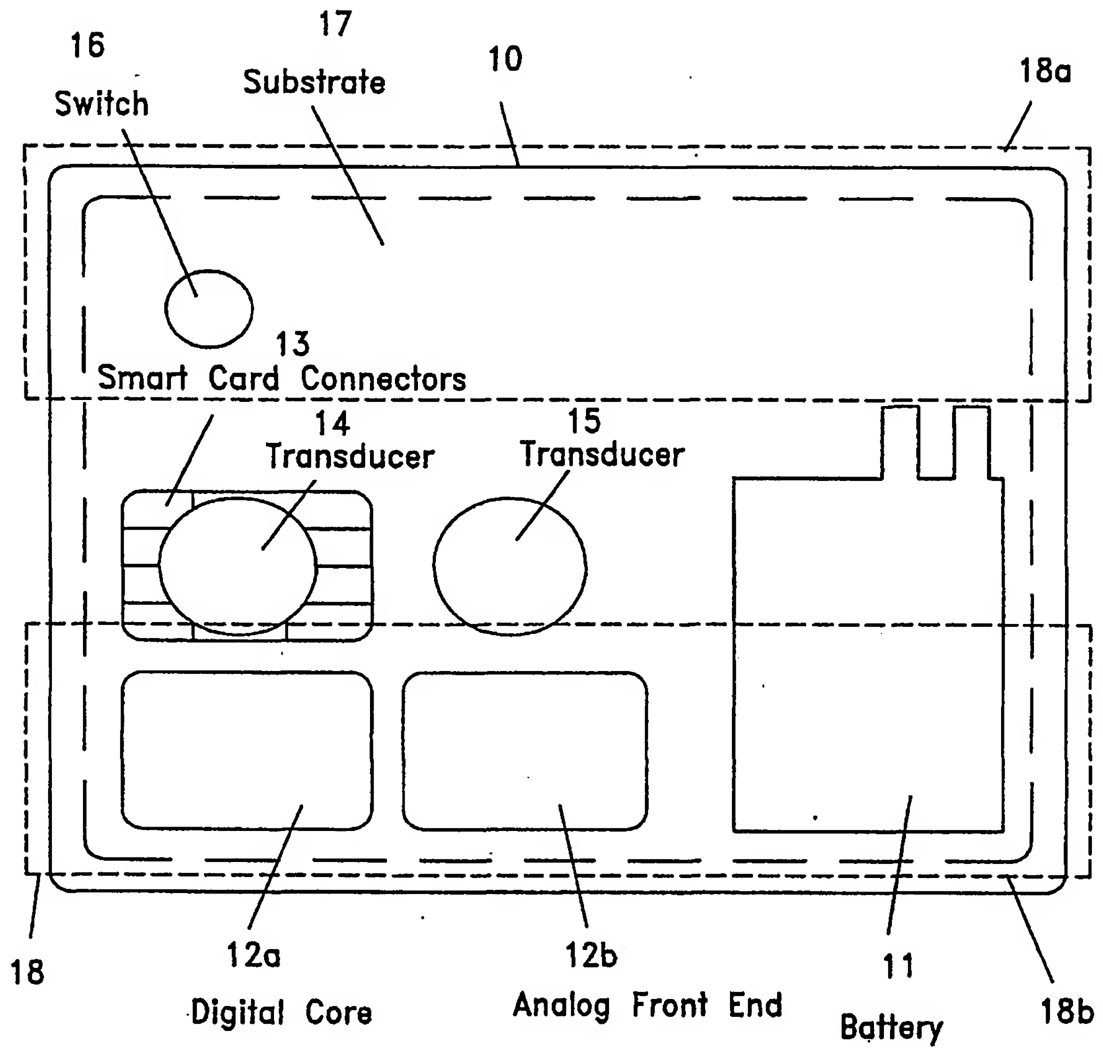

16
Switch
17
Substrate
10
18a
13
Smart Card Connectors
14
Transducer
15
Transducer
18
12a
Digital Core
12b
Analog Front End
11
Battery
18b

Fig. 1C

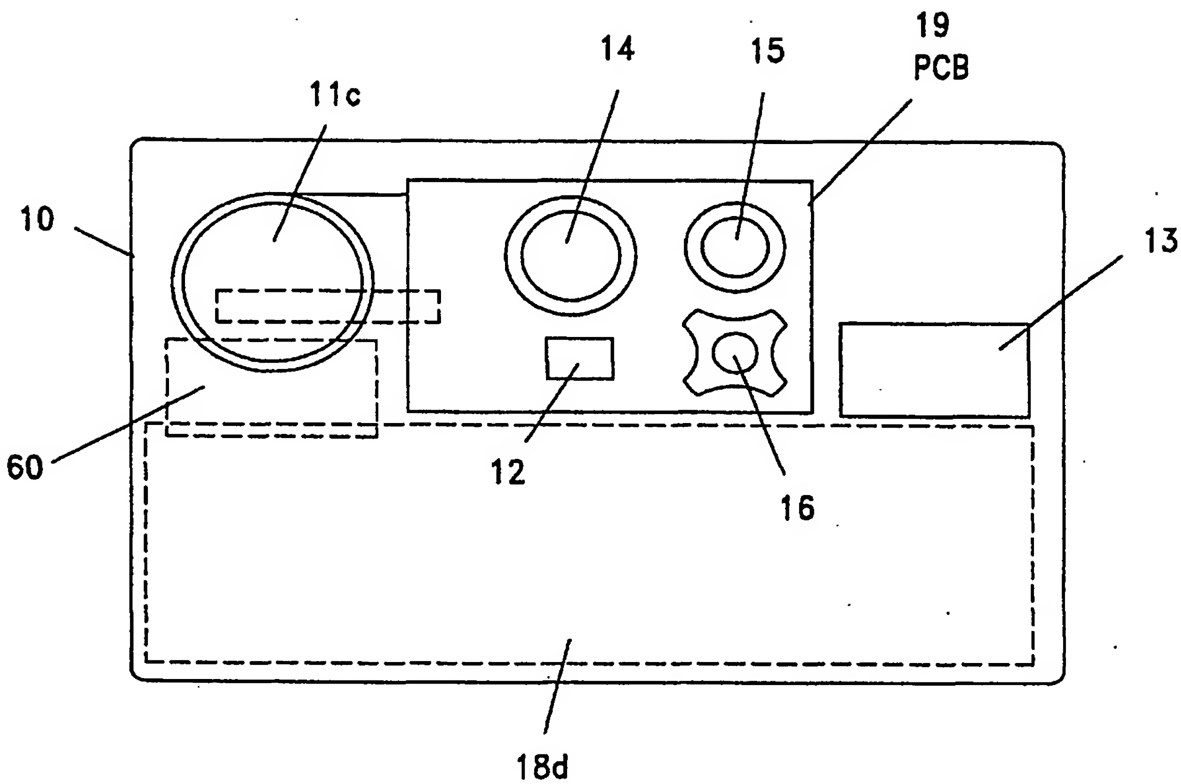


Fig. 1D

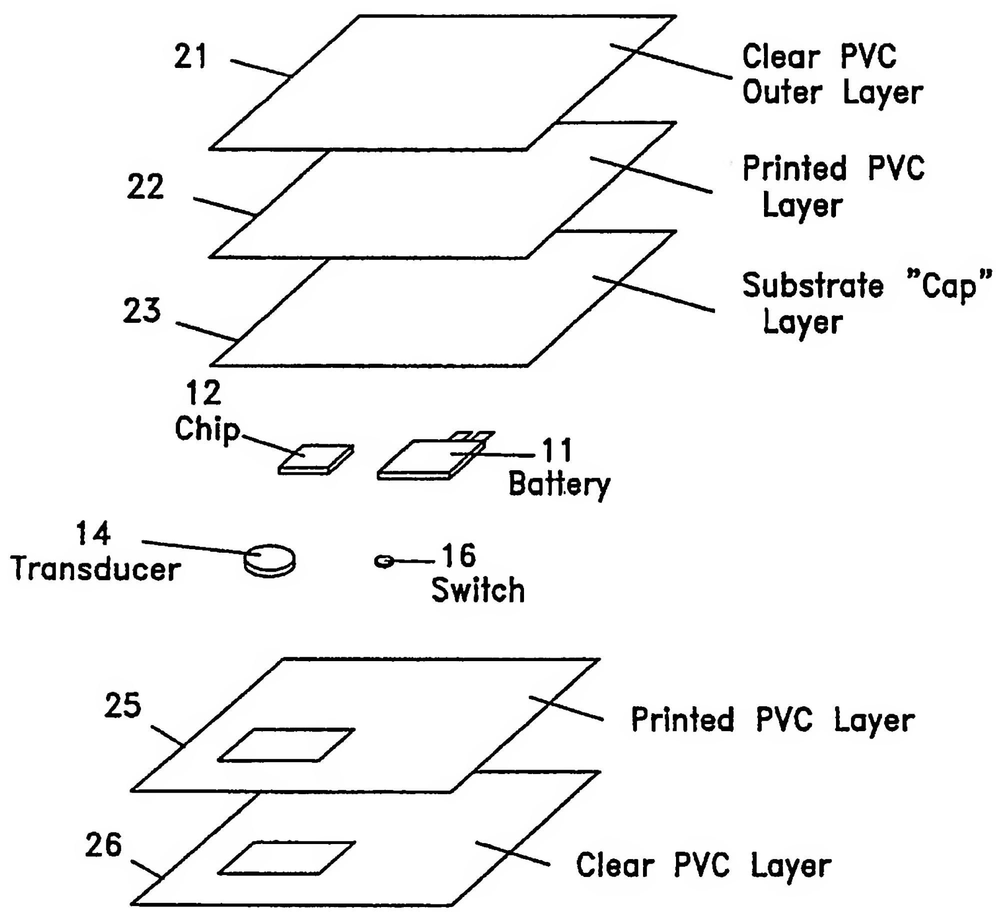

21
Clear PVC
Outer Layer
22
Printed PVC
Layer
23
Substrate "Cap"
Layer
12
Chip
11
Battery
14
Transducer
16
Switch
25
Printed PVC Layer
26
Clear PVC Layer

Fig. 2

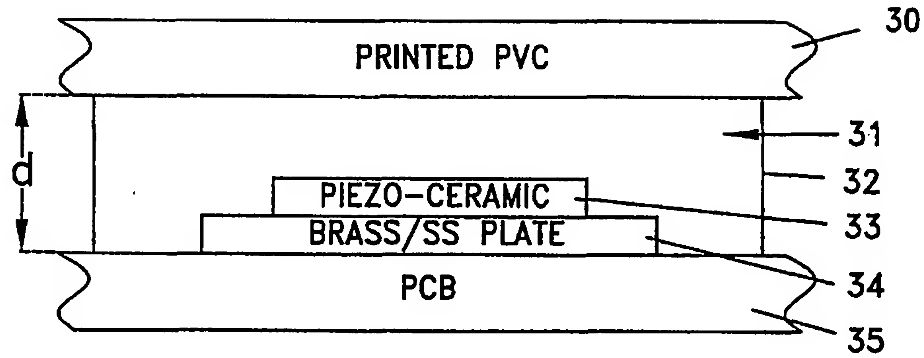


Fig. 3(A)

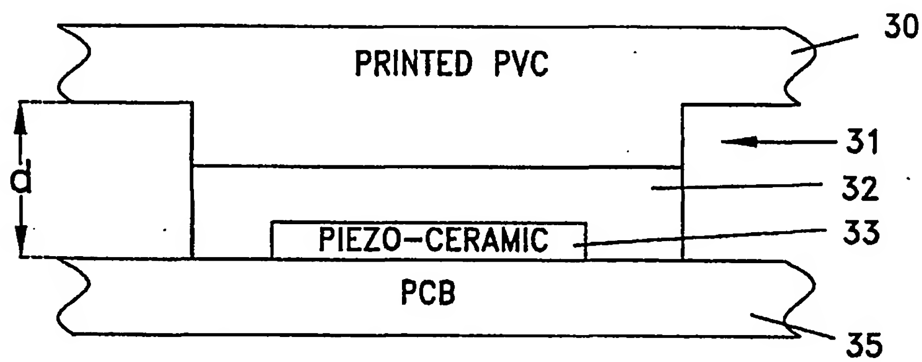


Fig. 3(B)

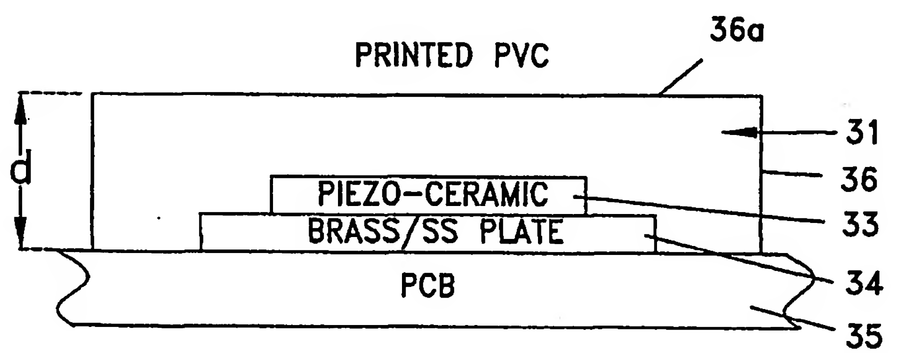
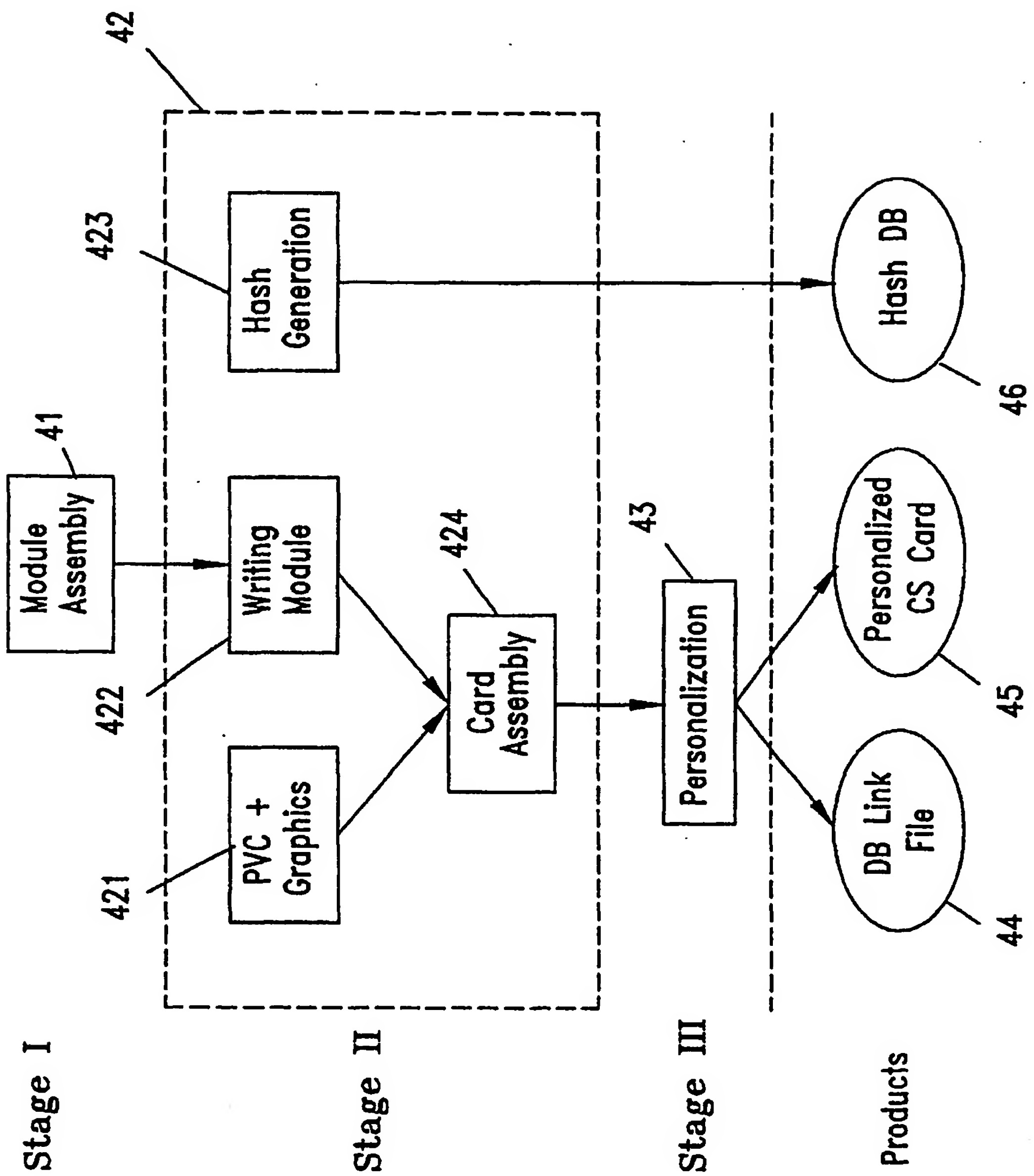


Fig. 3(C)


Stage I
Stage II
Stage III
Products
Module Assembly
41
42
PVC + Graphics
421
Writing Module
422
Hash Generation
423
Card Assembly
424
Personalization
43
DB Link File
44
Personalized CS Card
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Hash DB
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Fig. 4

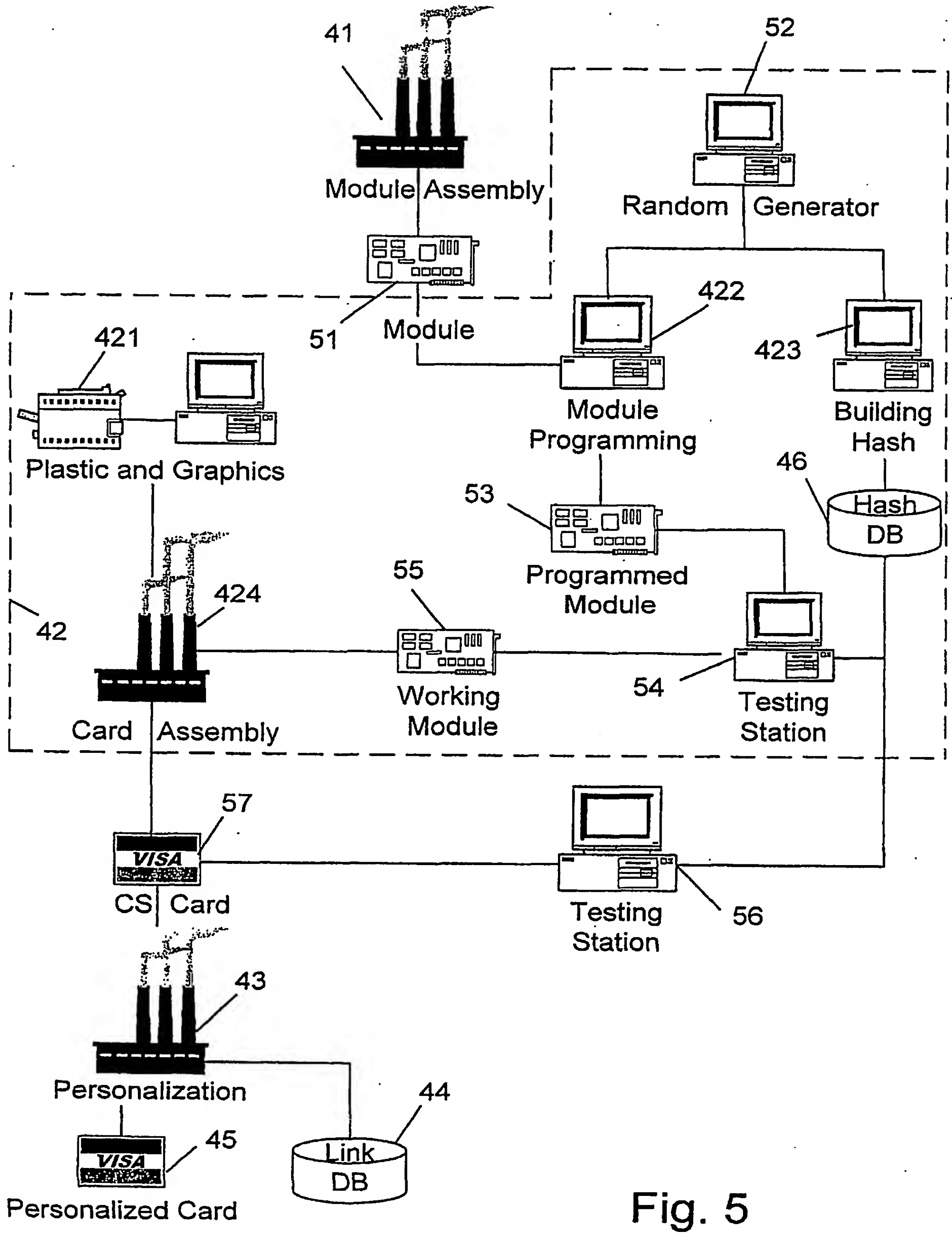
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Fig. 5